6.0 TIER III EVALUATION

Tier III testing assesses the impact of contaminants in the dredged material on appropriately sensitive and benchmark organisms to determine if there is the potential for an unacceptable (toxicity or bioaccumulation) impact at the disposal site. Lists of candidate test species (Sections 11 and 12: Tables 11-1 through 12-1) include consideration of: (1) appropriate sensitivity such that testing should not occur with insensitive organisms; (2) allowing appropriate Regional flexibility based on the list provided in this manual or the approved regional implementation manual; (3) providing some benchmark species for comparing (where appropriate) the sensitivity of regional species not widely used for such testing.

The Tier III assessment methods are bioassays (toxicity and bioaccumulation tests) (Figures 3-1 through 3-3). Generic guidance provided in this manual may have to be modified for specific species. Where possible and appropriate, organisms representative of the water column and benthic biota and conditions at the disposal site or the appropriate reference area should be used. Also, exposure routes must be appropriate (e.g., benthic test species must be truly benthic, that is, living on or in the sediment).

Presently, Tier III toxicity tests primarily use lethality as the endpoint. Chronic/sublethal tests for sediments are under development; none are considered to be currently suitable for wide-spread national use and hence are not included in this manual although regional use is allowed (cf. Section 11.2.3). New, appropriate benthic and water column tests, including sediment chronic/sublethal tests, will be included in future revisions of this manual as appropriate.

The recommended procedures for water-column toxicity tests (Figure 3-2) use appropriate sensitive water column organisms (Section 11.1.1, Table 11-1). The assay for benthic impact (Figure 3-3) uses deposited sediment and appropriately sensitive benthic organisms (Section 11.2.1, Table 11-2).

Bioaccumulation also has to be considered to fully evaluate potential benthic impact (Figure 3-3). The results of bioaccumulation tests are used to predict the potential for uptake of dredged-material contaminants by organisms (Kay, 1984).

Tier III information is usually sufficient for making factual determinations. Only in unusual cases is further information on toxicity or bioaccumulation (or both) necessary to make determinations under the Guidelines.

6.1 Water Column Toxicity Tests

Tier III (Figure 3-2) considers the effects on water column organisms, after allowance for mixing, of dissolved contaminants plus those associated with suspended particulates. The toxicity and mixing data results are generated as described in Section 11.1.

After considering the tests and considering mixing, one of the following conclusions is reached:

- If the 100% dredged material elutriate toxicity is not statistically higher than the dilution water (see Section 8.0, Table 8-1), the dredged material is not predicted to be acutely toxic to water column organisms.

- The concentration of dissolved plus suspended contaminants, after allowance for mixing, does not exceed 0.01 of the toxic (LC_{50} or EC_{50}) concentration beyond the boundaries of the mixing zone. Therefore the dredged material is predicted not to be acutely toxic to water column organisms. However, benthic impact has to be considered. If the information warrants, it is acceptable to determine water column effects at Tier III and benthic effects at another tier.

- The concentration of dissolved plus suspended contaminants, after allowance for mixing, exceeds 0.01 of the toxic (LC_{50} or EC_{50}) concentration beyond the boundaries of the mixing zone. Therefore, the dredged material is predicted to be acutely toxic to water column organisms.

6.2 Benthic Toxicity Tests

Evaluation of benthic (i.e., sediment) toxicity tests in Tier III (Figure 3-3) is based on data generated according to the guidance in Section 11.2. Dredged material is predicted to be acutely toxic to benthic organisms when mean test organism mortality:

- is statistically greater than in the reference sediment, and

- exceeds mortality (or other appropriate end point) in the reference sediment by at least 10% (the 10% value should be used unless a different value has been developed for specific test species and end-points for regulatory use, and is technically defensible; e.g.,

a 20% value for lethality can be used for the amphipods *Ampelisca abdita, Rhepoxynius abronius* and *Eohaustorius estuarius* (Swartz et al., 1985; Mearns et al., 1986; SAIC, 1992a,b)).

However, even if there is a certain level of toxicity (e.g., marginal mortalities for a single non-benchmark species), the preponderance of evidence could suggest that the sediment is not acutely toxic to benthic organisms. Acute toxicity testing of contaminants in the dredged material in Tier III will result in one of the following possible conclusions:

- Mortality (or other appropriate endpoint) in the dredged material is not statistically greater than in the reference sediment, or does not exceed mortality (or other appropriate endpoint) in the reference sediment by at least 10%. Therefore, the dredged material is predicted not to be acutely toxic to benthic organisms. However, bioaccumulation of contaminants also has to be considered. If the information warrants, it is acceptable to determine benthic toxicity at Tier III and bioaccumulation at another tier.

- Mortality (or other appropriate endpoint) in the dredged material is statistically greater than in the reference sediment and exceeds mortality (or other appropriate endpoint) in the reference sediment by at least 10%. In this case, the dredged material is predicted to be acutely toxic to benthic organisms.

6.3 Benthic Bioaccumulation

Body burdens of chemicals are of concern for both ecological and human health reasons. The Tier III benthic bioaccumulation tests (Section 12.1) are conducted for a subset of the contaminant of concern list based on the contaminant bioaccumulation properties discussed in Sections 4.2 and 10.2. These tests provide for the determination of bioavailability through 28-day exposure tests. For purposes of comparison with an action or tolerance level such as from Food and Drug Administration (FDA) as described below (or when conducting a Tier IV risk assessment), the duration of a bioaccumulation test should be sufficient for organisms to reach steady-state tissue residues for all compounds. However, the time to reach or approach steady-state varies among different compounds and, to a lesser extent, among species. Test designs that assure that steady-state has been attained require a large number of samples and substantial expense. As a cost-effective compromise, it is recommended that a 28 day exposure be used for the "standard" bedded sediment bioaccumulation test for neutral organics and metals.

Where it is desirable to know the steady-state concentration of neutral organic compounds as, for example, comparison to an FDA action level, fish advisory, or similar numerical values, the following procedure is recommended. The log Kow of the neutral organic compound of concern should be determined from Section 9.5.1 (Table 9-5). This should be compared with the log Kow in Figure 6-1 and will indicate the proportion of steady-state concentration (Css) expected in 28 days. This will allow estimation of the steady-state value from the 28-day laboratory exposure data through the use of a steady-state correction factor. The correction factor is the reciprocal of the decimal fraction indicating the proportion of Css expected in 28 days.

Bioaccumulation of most compounds, if it occurs, will be detectable after the 28-day exposure period, even though steady state may not have been reached. Thus, Tier III bioaccumulation tests provide useful information about the potential for bioaccumulation (i.e., bioavailability), even when steady-state tissue residues are not determined, e.g. when comparing to a reference sediment.

Concentrations of contaminants of concern in tissues of benthic organisms following dredged material exposure are compared to applicable Food and Drug Administration (FDA) Action or Tolerance Levels for Poisonous or Deleterious Substances in Fish and Shellfish for Human Food, when such levels (i.e., limits) have been set for the contaminants. The FDA levels (Table 6-1) are based on human-health as well as economic considerations (21 CFR 109 and 509), but do not indicate the potential for environmental impact on the contaminated organisms or the potential for biomagnification. Because contamination of food in excess of FDA levels is considered a threat to human health, EPA and USACE consider concentrations in excess of such levels in any test species to be predictive of benthic bioaccumulation of contaminants. This guidance applies even though the test species may not be a typical human food item partly because certain contaminants can be transferred through aquatic food webs, but mainly because uptake to FDA levels in relatively short term tests with one species may indicate the potential for accumulation in other species.

Based on tissue comparisons with FDA levels, one of the following conclusions is reached:

- Tissue concentrations of one or more contaminants are not statistically less than the FDA levels. Therefore, the dredged material is predicted to result in benthic bioaccumulation of contaminants.

- Tissue concentrations of all contaminants either are statistically less than FDA levels or there are no FDA levels for the contaminants. In this case, the information is insufficient to reach a conclusion with respect to benthic bioaccumulation of contaminants. The

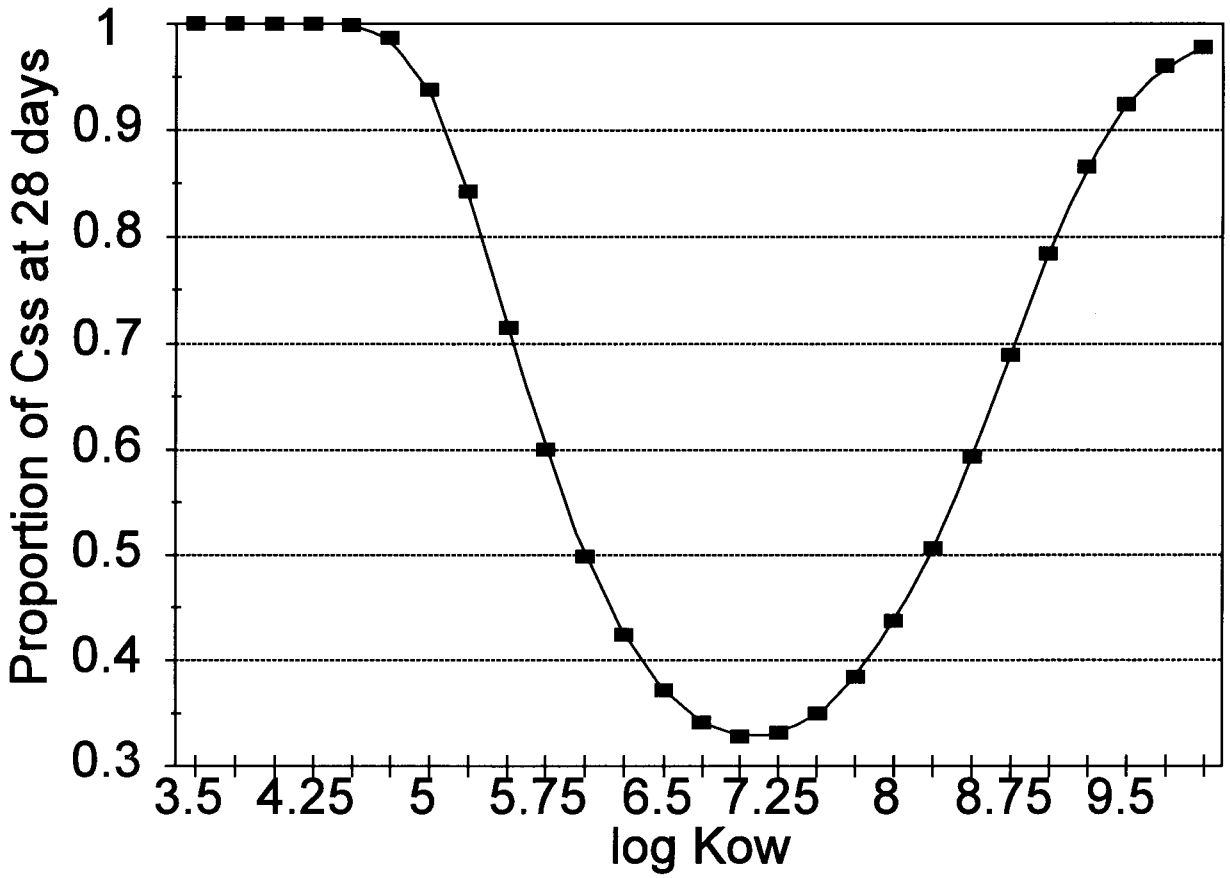


Figure 6-1. Expected proportion of steady-state concentration (Css) of neutral organic compounds reached in 28-day laboratory exposures. The proportion is a function of the log Kow of the compound of interest. Consult Section 9.5.1 (Table 9-5) for appropriate log Kow values. Figure adapted from McFarland (1994).

Table 6-1. Food and Drug Administration (FDA) Action Levels for Poisonous and Deleterious Substances in Fish and Shellfish for Human Food.[a]

Substance	Action Level[b]
Metals	
Methyl Mercury	1.0 ppm
Pesticides	
Chlordane	0.3 ppm
Chlordecone (Kepone)	0.3 ppm
DDT + DDE	5.0 ppm
Dieldrin + Aldrin	0.3 ppm
Heptachlor + Heptachlor Epoxide	0.3 ppm
Mirex	0.1 ppm
Industrial Chemicals	
PCBs[c]	(2.0 ppm)

[a] Action levels are established, revised, and revoked through notices published in the Federal Register. It is the responsibility of the users of the list to keep up to date on any amendments to this list. For further information on current action levels, users may contact the Food and Drug Administration, Center for Food Safety and Applied Nutrition, Industry Programs Branch [HFF-326, 200 C Street, S.W., Washington, DC 10204; (202) 205-5251].

[b] Action levels are reported in wet weight.

[c] There is no FDA action level for PCBs as a tolerance level has now been established (21 CFR part 109.30), which is equal to the previous action level.

dredged material needs to be further evaluated in Tier III as described below for bioaccumulation potential to furnish information to make determinations under the Guidelines.

Tissue contaminant concentrations following exposure to dredged material which are statistically less than FDA levels, or for which there are no such levels, are compared to tissue contaminant concentrations for organisms similarly exposed to reference sediment. One of the following conclusions is reached based on this comparison:

- Tissue concentrations of contaminants of concern in organisms exposed to dredged material do not statistically exceed those of organisms exposed to the reference sediment; therefore, the dredged material is predicted not to result in benthic bioaccumulation of contaminants. However, benthic toxicity effects also have to be considered.

- Tissue concentrations of contaminants of concern in organisms exposed to dredged material statistically exceed those of organisms exposed to the reference material. In this case, the final conclusion regarding benthic bioaccumulation of contaminants would be based upon technical evaluations that emphasize the various factors deemed appropriate in a particular region (see last paragraph in this section). Additional testing (Tier IV) may be required.

One other possibility exists: tissue concentrations are above FDA limits but are not statistically different from the reference (or disposal) site. This situation represents an exceptional case which can only be dealt with at the regional level.

The above comparisons to FDA values address human health concerns, and follow from EPA/USACE (1991). Other approaches which should be considered in addition to the use of FDA values include comparisons to state fish advisories, cancer and non-cancer risk models, existing ambient fish concentration data. State fish advisories exist for the following chemicals for which EPA risk-based screening values are being developed: (carcinogens) chlordane, DDT, dieldrin, hexachlorobenzene, lindane, toxaphene, PAH, PCBs, 2,3,7,8-TCDD; (noncarcinogens) endosulfan, mirex, cadmium, mercury, selenium, endrin. Methods to calculate carcinogenic and non-carcinogenic health risks are summarized in EPA (1989a). "Computerized Risk and Bioaccumulation System", an expert system for PC computers, is available to predict tissue residues in sediment-dwelling shellfish and the associated excess cancer risk (Lee et al., 1990). Note that this program does not calculate risks associated with mobile invertebrates or fishes, and that it should be used only to supplement data derived from other methods.

Reference comparisons are made for the protection of aquatic life as well as human health because bioaccumulation is both undesirable and an indicator of bioavailability (Figure 3-3). It is recognized that residue effects information does not exist to fully interpret bioaccumulation data; the approach followed in this manual is the best presently available.

When the bioaccumulation of contaminants in dredged-material tests statistically exceeds that in reference-material tests, five factors should be assessed. Where available, regional guidance should be consulted regarding the relative importance of these factors:

- What is the toxicological importance of the contaminants (e.g., Do they biomagnify? Do they have effects at low concentrations?) whose bioaccumulation from the dredged material statistically exceeds that from the reference material?

- By what magnitude does bioaccumulation from the dredged material exceed bioaccumulation from the reference material?

- What is the propensity for the contaminants with statistically significant bioaccumulation to biomagnify within aquatic food webs (Kay, 1984)? Contaminants which biomagnify appear to be few in number but widespread, and include DDT, PCB, methylmercury and, possibly, dioxins and furans.

- What is the magnitude by which contaminants whose bioaccumulation from the dredged material exceeds that from the reference material also exceeds the concentrations found in comparable species living in the vicinity of the proposed disposal site?

- For how many contaminants is bioaccumulation from the dredged material statistically greater than bioaccumulation from the reference material?

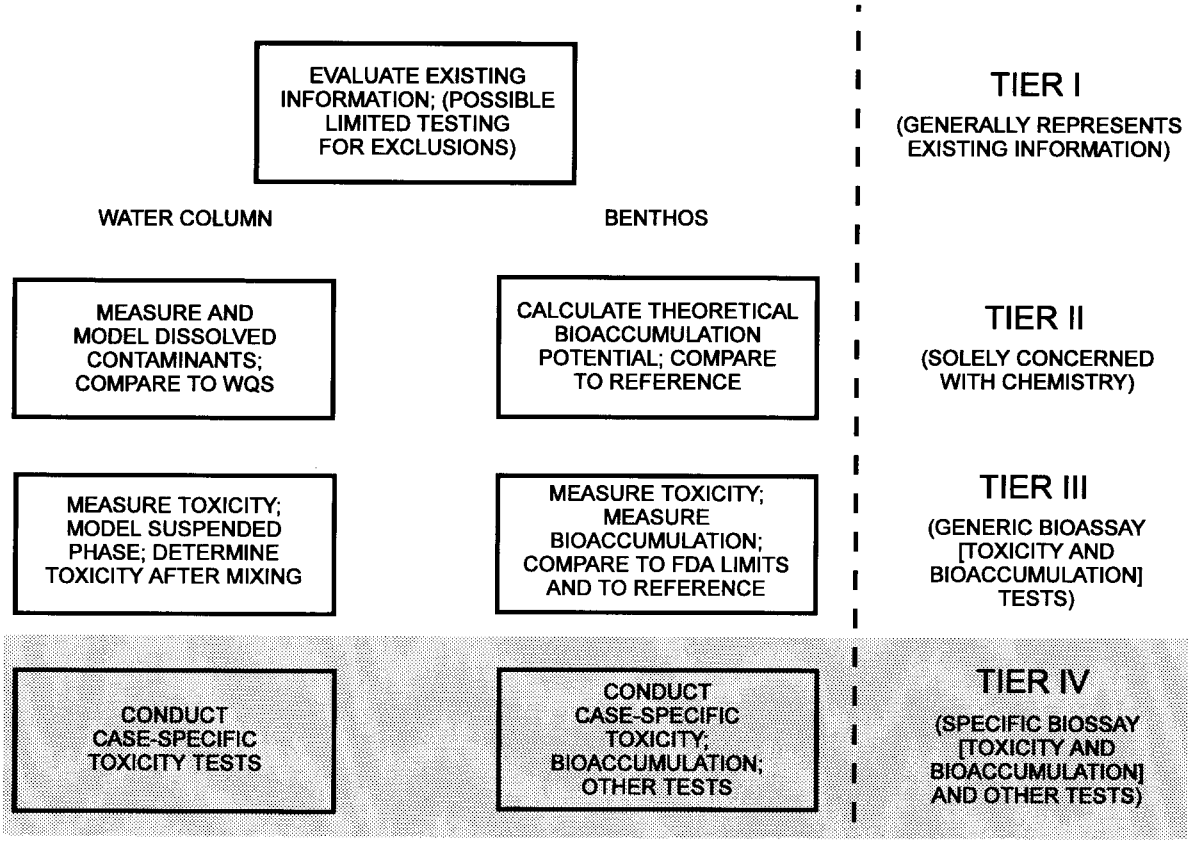
6.4 Tier III Conclusions

The above five factors and perhaps other factors are complexly interrelated; i.e., the importance of each factor depends on its interaction with all other factors. These factors have to be considered in case-specific determinations (if needed) for dredged material assessed for bioaccumulation in the final step of Tier III. After considering these factors, one of the following Tier III conclusions is reached:

- Discharge of the dredged material is predicted not to result in above-reference toxicity or benthic bioaccumulation of contaminants.

- Discharge of the dredged material is predicted to result in above-reference toxicity or bioaccumulation of contaminants.

- Further information is needed to make factual determinations, specifically in Tier IV.


EVALUATE EXISTING INFORMATION; (POSSIBLE LIMITED TESTING FOR EXCLUSIONS)
TIER I
(GENERALLY REPRESENTS EXISTING INFORMATION)
WATER COLUMN
BENTHOS
MEASURE AND MODEL DISSOLVED CONTAMINANTS; COMPARE TO WQS
CALCULATE THEORETICAL BIOACCUMULATION POTENTIAL; COMPARE TO REFERENCE
TIER II
(SOLELY CONCERNED WITH CHEMISTRY)
MEASURE TOXICITY; MODEL SUSPENDED PHASE; DETERMINE TOXICITY AFTER MIXING
MEASURE TOXICITY; MEASURE BIOACCUMULATION; COMPARE TO FDA LIMITS AND TO REFERENCE
TIER III
(GENERIC BIOASSAY [TOXICITY AND BIOACCUMULATION] TESTS)
CONDUCT CASE-SPECIFIC TOXICITY TESTS
CONDUCT CASE-SPECIFIC TOXICITY; BIOACCUMULATION; OTHER TESTS
TIER IV
(SPECIFIC BIOSSAY [TOXICITY AND BIOACCUMULATION] AND OTHER TESTS)